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Bleeding of Cod on Board Factory Trawlers

by W. Flechtenmacher*

with 11 illustrations received 30 January 1975

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*Dedicated to Professor Th. E. Schmidt, Dr.-Ing. [engineering] on the occasion of his seventieth birthday.

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1. Purpose of Study

In a competitive market, the fish-processing industry strives to produce light-coloured deep-frozen fish products. As well, the use of fish well-drained of blood is necessary to preserve the quality of deep-frozen fish since residual blood in the flesh causes changes in colour and odour, and oxidation, and hence deterioration in quality during the storage period.

With reference to the production of deep-frozen products from freshly caught fish on board a factory trawler, it has become desirable to determine whether, and by what means, thorough exsanguination could be effected before fish was deep-frozen.

2. Previous Studies and Results Reported in the Literature

Earlier experiments, carried out in a different context (1), have shown that the nature of the slaughtering process does not influence the bleeding effect. It was proven that it was impossible to obtain light-coloured products from cod which had been packed in ice on a deep-sea fishing trawler and, upon being landed, was sectioned at right angles to the spine, vacuum-packed, and deep-frozen. The vacuum drew residual blood to the surface of the flesh underneath the packaging film, with the result that the package looked unattractive and could not be sold. This, primarily optical, drawback was eliminated in the course of the study by using special methods to bleed the fish immediately upon hauling the catch on board ship. The best bleeding effect was produced by bleeding freshly caught fish, immediately upon hauling in the nets, by cutting their throats but without gutting them, and putting them in

cooled, running sea water until the blood had been exuded. Fish are quickly killed by a cut to the throat, thus opening the artery while the heart continues to beat and helps to empty the blood vessels of their contents. This effect of coronary activity has also been observed in studies of warm-blooded animals where "thorough drainage of blood is inseparably linked to a strongly beating heart" (6).

A parallel experiment, also using freshly caught but completely gutted fish, drained of blood under otherwise similar conditions, also yielded good results. When the gutted fish were drained of blood in the air rather than in water, the difference from the two previous procedures manifested itself in a slight reddening of the cut surfaces after the fish had been vacuum-packed (1).

Other investigations into the bleeding of cod (2) essentially confirmed the findings of (1). Here too, exsanguination by a cut to the throat produced the best results. It was also found that better results were achieved by the use of a gutting machine than by the traditional gutting by hand. A definite difference between allowing the blood to drain in the air rather than in water was not demonstrated, however. In each case, immediate exsanguination proved more effective than exsanguination at a later time, delayed sometimes by as much as four hours after the fish were caught.

3. Conditions Encountered in Practice

As the investigations described as (1) and (2) show, thorough exsanguination is largely dependent on the fish being alive when the

blood is drained. Similarly, it is a well-established fact that the degree to which warm-blooded animals can be drained of blood diminishes considerably when the animals, in the spasmodic rough-and-tumble of an abattoir, have been left lying for some time before they are bled (6). Conditions on board a factory trawler at times when fish has to be processed are, almost inevitably, very much the same.

The processing operation on board is such that only a part of the haul, depending on its size, can be processed while the fish are still alive. Because of the high labour content involved and the limited availability of personnel, space, and machines on board, it is usually not possible to bleed more than a certain portion of the haul within a relatively short time, beginning immediately after the net has been hauled in.

Assuming that the net is emptied of fish of undiminished vitality, their activeness decreases with increasing time spent lying on deck until they are bled. The time on deck must therefore be seen as an important factor of the bleeding effect.

Another important factor is the actually very diverse vitality of fish at the time of being unloaded from the net. Their vitality varies depending on the degree to which the fish have become fatigued or exhausted while being trawled. In extreme cases, the fish may even be dead or in rigor mortis when emptied from the net. Thus, a highly heterogeneous situation, adverse to the uniform bleeding of the fish, arises the moment the net is emptied. We may therefore assume that only a limited portion of the haul processed by a factory trawler will yield

products from which blood has been drained to a uniform degree. If we also take into consideration the fact that blood constitutes only 1/63 of the body weight of fish or 1.6%, (5) in contrast to warm-blooded animals, where blood constitutes between 5 and 10% of the dressed weight (5), and in view of the heterogeneous condition in which the catch arrives on board, the task of finding a satisfactory solution to the problem of bleeding fish seems a difficult one.

Given the conditions on board a factory trawler, the question, in practical terms, is: within what period of time can live fish - in this case, cod - be drained of blood to an extent that may be considered sufficient to produce a light-coloured flesh of a quality largely unimpaired by residual blood. The following tests were designed to shed light on this question.

4. Preliminary Tests

During three voyages (first voyage: August/September 1971*, second voyage March 1972*, third voyage: July 1972) preliminary tests were carried out aboard the factory trawler Walther Herwig. They were designed to determine the bleeding effect in cod by collecting the blood exuded when the fish were bled and calculating its ratio to the total weight of the fish in percent. The quantity of blood exuded was determined in dependence on two variables,

a) in dependence on the time elapsed between emptying the nets and starting to bleed the fish, during which time they lay on deck.

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*Kind efforts by the Institute for Fishing Techniques of the Federal Fisheries Research Establishing in preparing the material used in these tests are gratefully acknowledged.

This period ranged from 0 to 2½ hours and 4½ hours. Time allowed for blood to drain was a constant 30 minutes,

b) in dependence on the time allowed for blood to drain, ranging from 15 minutes to 3½ hours, with time elapsed between unloading of the net and the start of exsanguination a constant 15 minutes.

To facilitate the collection of the exuded blood in a plastic pouch, a fish was deheaded immediately after being weighed and measured, put in a plastic bag, and suspended by the caudal fin for a predetermined period allotted for exsanguination. At the end of this period, the fish now drained of blood, was removed from the plastic bag, put into another one, and frozen together with the sealed bag containing the blood. After a predetermined interval, the second fish was processed, then the third, and successive ones in a test series, until the series, usually consisting of ten fishes, had been processed. A total of 72 fishes were processed in this manner.

The findings were subsequently evaluated by a laboratory on land. Due to the extraordinarily wide dispersion of the data obtained by the preliminary test, no significant dependence of the amount of exuded blood on the beginning of exsanguination or the duration thereof, was recognized. The same applied to the visual evaluation of fillets cut from the fishes used for the test which showed that there was only a minor tendency toward greater frequency of light-coloured flesh among fillets from fish that had been bled without delay.

The probable cause for the lack of exactitude of the method is, above all, the low blood content of fish, possible errors in the measured weight of blood due to blood being lost through deheading, the admixture of mucus, and the fact that it is impossible to sever the head always at the same anatomical location, and that the heart is usually severed from the body of the fish, along with the head. In addition, the weight of the whole fish is influenced by its state of nourishment, age, sex, and developmental stage. Last but not least, there are the effects of the unknown degree of fatigue or exhaustion of an individual at the moment of removal from the net.

Subsequent tests therefore employed a different method which, in a previous test (1), had proved to be a relatively sensitive indicator of blood in the product. Here, the gutted fish, after having been drained of blood, is sliced at right angles to the spine and vacuum-packed in plastic film. Forced by the vacuum to rise to the surface under the plastic foil wrap, the blood becomes visible.

5. Main Tests

In order to determine the length of time during which cod can be bled to a sufficient degree, it was essential to eliminate, as far as possible, interfering factors which manifested themselves in the preliminary test and the inhomogeneities of the tested material which have to be expected on board ship.

To obtain a conclusive answer to this question, the cut to the throat - known to be the most effective - and exsanguination in running water

were the methods chosen. The inhomogeneities in the vitality of fish unloaded from the net were avoided by conducting the experiments at the Institute, using live fish. Cod (Baltic cod) measuring between 40 and 70 cm, caught in stationary nets in the fishing grounds off Fehmarn between March and May 1973 were held live in sea-water tanks while on board the trawler and while being transported overland to the Institute. The distance of approximately 150 km between Fehrmarn and Hamburg was covered at a relatively low speed by trucks carrying up to 20 fishes in a sea-water aquarium holding 1 m^3 into which oxygen was pumped at a constant rate. Because of this, we may assume that all test fishes were at the same level of vitality or fatigue at the beginning of the experiment, i.e. that inhomogeneity in this respect had been greatly decreased.

5.1. Testing Procedure at the Institute, Using Cod

As in the preliminary tests carried out on board, the tests at the Institute evaluated the bleeding effect in dependence on time elapsed since removal of the fish from the tank and a constant exsanguination time of 30 minutes. The moment of removal from the tank corresponds to the moment of unloading from the net on board ship.

Exsanguination began after the fishes had been left lying in the air for varying periods of time, ranging from 0 to 4½ hours. After the time allotted for exsanguination, each fish, drained of blood, was immediately gutted and cut at right angles to the spine into approximately 2 cm thick slices; four slices from the head end, and four from the tail end of the each fish were then washed and, after draining,

packed in a plastic bag (Hostaphan-PE 12/75) with a vacuum-packing machine, and subsequently frozen for storage.

Before being frozen, the samples were left in the unfrozen state for one hour to allow the vacuum to take full effect, i.e. to allow residual blood to appear on the surface of the samples, underneath the plastic wrap. Figs. 1 to 8 give an overview of the testing procedure.

5.2. Criteria for the Evaluation of Exsanguinated, Frozen Fish Samples

The visual appearance of vacuum-packed, frozen fish slices was graded as follows:

Grade for dominant colour perceived

1 light-coloured
2 light-coloured to pale pink
3 pale pink
4 pink
5 pale red
6 red
7 very red

the vitality of the fishes before treatment, i.e. immediately before the throat was slashed:

Grade for vitality

1 flapping violently

2 flapping strongly

3 flapping slightly

4 stopped flapping, but still alive

5 dead but not stiff

6 rigor mortis setting in

7 in rigor mortis

and the intensity of the bleeding after throat had been slashed:

Grade for intensity of bleeding

1 very profuse

2 profuse

3 moderate

4 slight

5 very slight

6 practically none

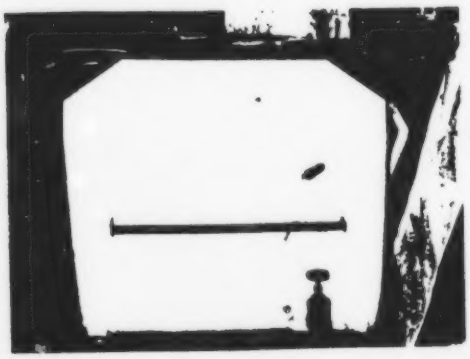

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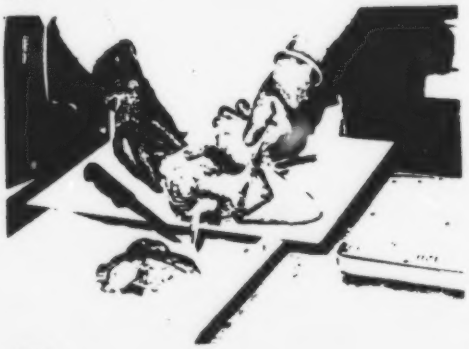
Abb. 2



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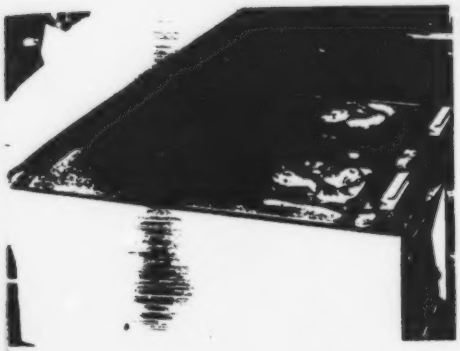

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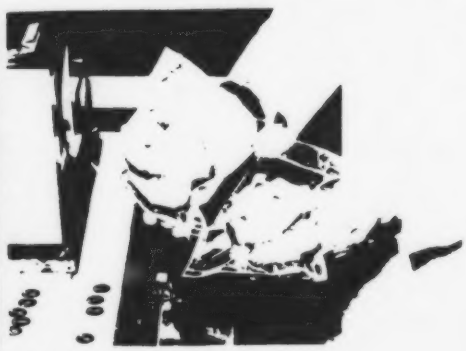

Abb. 8

Fig.1: Movable sea-water aquarium
Fig.2: Cod bled by cut to the throat
Fig.3: Gutting of cod after exsanguination
Fig.4: Bled and gutted cod being sliced at right angles to spine
Fig.5: Slices cut from bled and gutted fish are washed,
Fig.6: and after surface water has run off, are packed in plastic bags
Fig.7: The bags are inserted in vacuum-packing machine
Fig.8: The packages after removal from the vacuum-packing machine

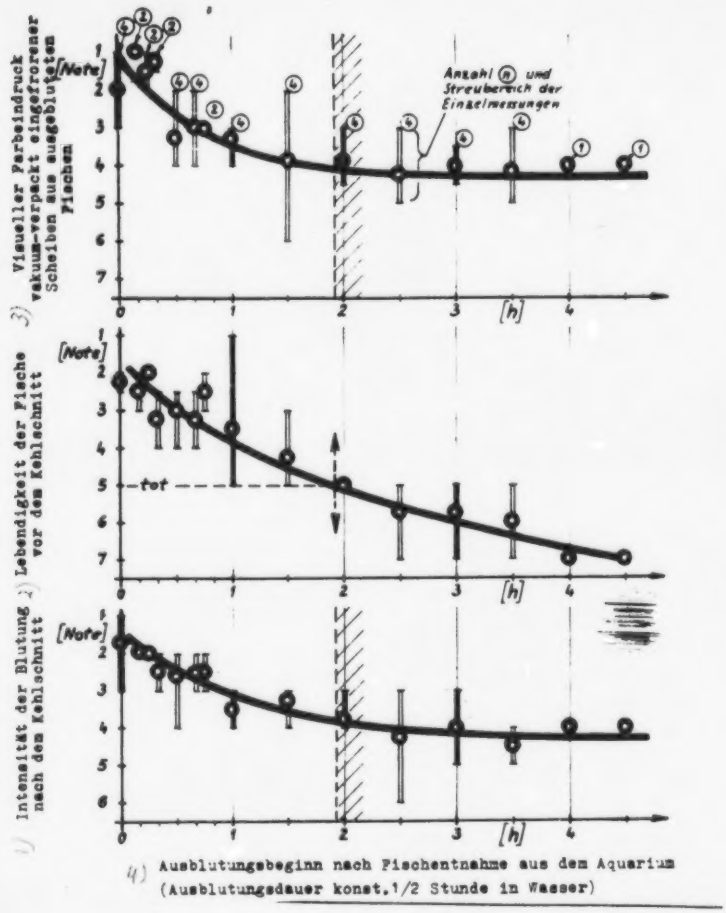

Fig. 9: Evaluation of exsanguination of cod through cut to the throat (arithmetic mean of 4 laboratory test-series)

(Key to diagrams:

1) intensity of bleeding following cut to throat
2) vitality of fishes before cut to throat administered
3) visual perception of colour of vacuum-packed, frozen slices of exsanguinated fish

4) begin of exsanguination after removal from aquarium
Period allowed for exsanguination: constant 30 minutes in water

5) number and distribution of individual values

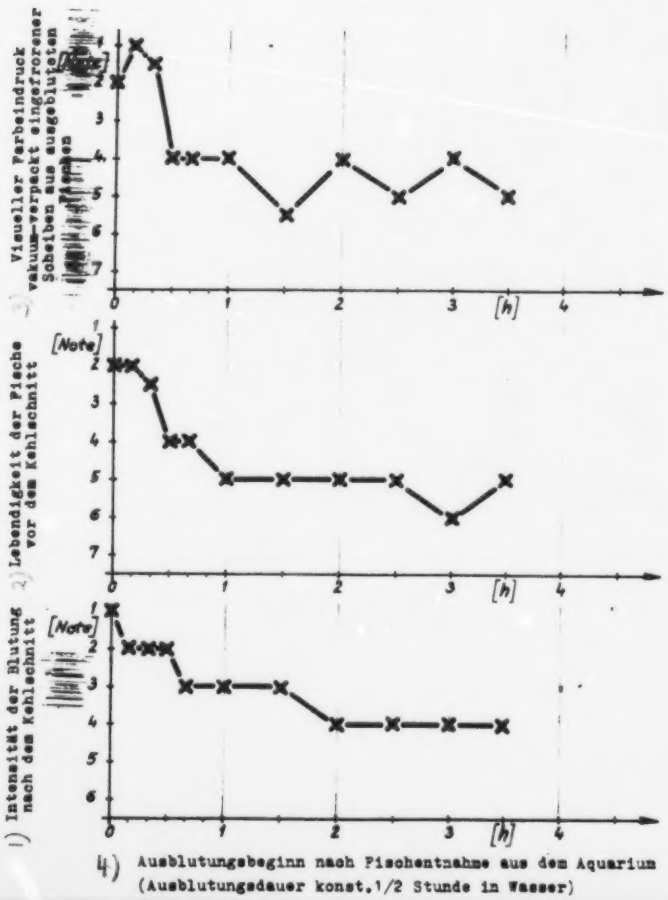

Fig.10: Evaluation of exsanguination of cod through cut to the throat (laboratory test with individual fish)

5.3. Results

Fig. 9 gives the arithmetical mean of the three criteria for four test series using a total of 48 cod, in dependence on the start of the exsanguination period, and Fig. 10, the corresponding values for a single test series from Fig. 9. These results clearly show the expected correlation between a diminished bleeding effect and the delay in the start of exsanguination. As can be seen, exsanguination of a live cod within 30 minutes of being caught produces a relatively light-coloured flesh, corresponding to the degree of exsanguination of the cross-section of the gutted whole fish, cut at right angles to the spine. The difference in the colour of samples that had been bled within 15 minutes after being caught, and those in which exsanguination had been delayed by 90 to 120 minutes clearly showed the detrimental effect of this delay: namely visible residual blood.

To get an indication of the effect of species-dependent influences and variations of, for example, vitality and resistance, on the bleeding effect, trout* were subjected to the same test as the cod. Fig. 11 gives the arithmetic mean for 4 test series, using a total of 45 trout, and exhibits the same tendency of the criteria as Fig. 9 for cod. In trout, however, the bleeding effect decreases faster with an increasing delay between the fish being caught and being bled, which is consistent with the lower resistance, i.e. the more rapid loss of activeness in trout.

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*Our thanks to the Institute of Coast and Inland Fishing of the Federal Fisheries Research Establishment for providing the material for this test.

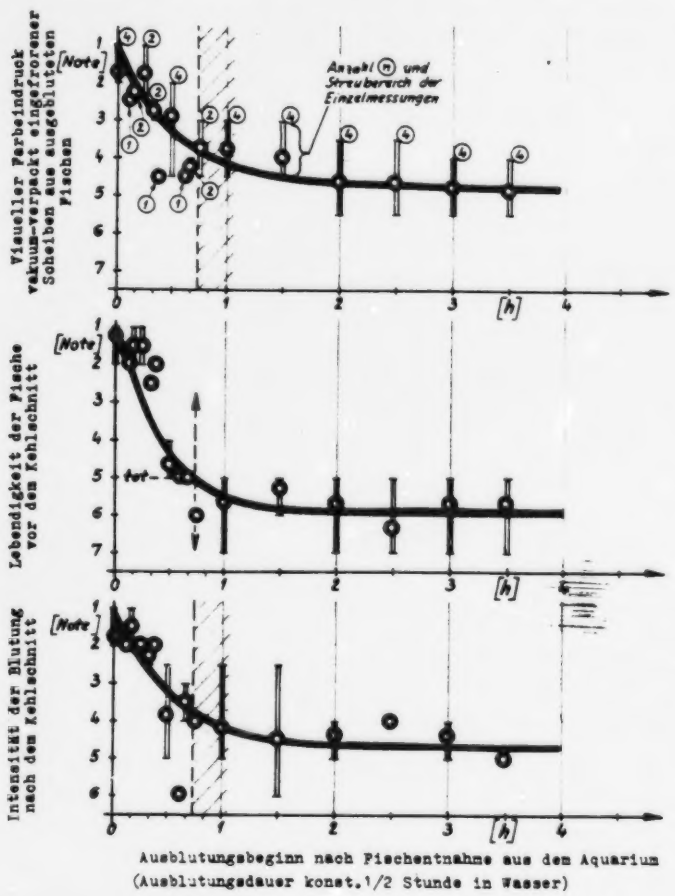

Fig: 11:Evaluation of exsanguination of trout through a cut to the throat arthmetic mean from four laboratory test series)

(for key please see p. 12)

6. Conclusion

As the study shows, the degree of exsanguination of cod which may be described as sufficient - with reference to the whole, gutted fish - is possible only within approximately 30 minutes from the time the fish is caught, and presupposes live fish. The heterogeneous condition of a catch the moment it is discharged from the net aboard a factory trawler necessarily robs this statement of much of its practical implication. We have to realize that the usually relatively large capacity of the nets means that only a limited quantity of uniformly exsanguinated products can be produced on board a factory trawler. If we consider that the bleeding effect in warm-blooded animals (6) drops considerably after a delay of only 18 minutes from the time the animal is stunned and it being bled (100% of blood exuded after 1 minute, 76% after 18 minutes), a corresponding effect has to be expected in fish with their very much lower blood content. The tests described above confirm this.

The method employed in the preliminary tests for determining the quantities of blood exuded by cod proved to be of insufficient exactitude in that it registered only about one third of the blood content of the fish (5), thereby giving exaggerated effect to sources of error. In the main test, visual colour perception together with the observable vitality of the fish and the intensity of exsanguination were evaluated. The vacuum method, considered to be sufficiently sensitive to make residual blood visible, permits conclusions to be drawn on the basis of relatively few samples; in the present case, a total of 93 fishes - 48 cod and 45 trouts - were processed for the main tests in the laboratory. The method registered the residual blood which became

visible in a cross section of the fish when cut at right angles to the spine after the fish was gutted. This residual blood, which is a determinant factor in the quality of the fish, is taken as the criterion for residual blood in fillets. Comparisons with other results (2 and 7) confirm the validity of this inference.

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7. Literature

(1) Deep-freezing of untreated fish packed in portions

(3) Fish must be drained of blood

(5) Manual of animal-derived food inspection

(6) Coronary activity and the emptying of blood vessels in delayed bleeding of slaughter animals.